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Kumars Zand-Parsa
California State University/ ACI/ Caltrop, Inc., Long Beach, CA

Kamran Zand-Parsa
Rayca System Inc., Iran

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Kumars Zand-Parsa
California State umm university/ACI Faculty/
Caltrop Inc., Long Beach, CA. 90732, U.S.A.

Kamran Zand-Parsa
Rayca System Inc.,
Tehran. 19177, Iran

ABSTRACT

Tieback retaining walls are using as temporary shoring systems for bridge footings or other structures that need deep excavations. Design and design review process are time consuming, and the possibility of making mistakes encourages us to find a simplified method for designing the tieback walls. Tieback walls with maximum 20m height and with 1 to 4 rows of anchors is considered in this paper. Whole length of the drilled holes will be filled with grout after setting the rods or stressing cables. Sometimes for temporary shoring the rod will be anchored to a concrete block supported by dirt, so there would be no need to grout the hole. Steel plate or wood timber lagging or steel mesh along with shotcrete will be used between the shoring piles (soldier piles).

The simplified KZP6 method is based on the soil mechanic concepts for the granular and cohesive soils and the Boussinesq strip load method for the possible surcharge behind the wall. In this paper besides considering the simplified method (KZP6) an example will be solved based on our simplified method and will be compared with the conventional method results to show the accuracy of the results.

INTRODUCTION

Tiebacks are used in both temporary and permanent structures. The use of tiebacks with sheet pile or soldier beam shoring permits higher walls and deeper excavations than are possible with cantilever type construction. The overall stability of anchored shoring systems and the required strength of its members depends on the interaction of a number of factors, such as the relative stiffness of the members, the depth of piling penetration, the stiffness and strength of the soil, the length of tiebacks, or tierods and the amount on anchor movement. Most of the current design methods for tieback retaining structures are derived from classical slope stability analysis methods modified to incorporate the additional soldier pile resisting forces provided by the tieback tensile reinforcement. These methods of analysis evaluate global system stability along assumed failure surfaces.

SIMPLIFIED KZP6 METHOD

Linear failure surface along with the tensile resistance of the tieback crossing the failure surface are used in KZP6 simplified method for shoring systems with active anchors. Shear and moment stability of the soldier pile (retaining structure) accordance with the number of tieback tiers will be calculated, and with global (overall) system stability the length of the tiebacks will be finalized. Figure 1 shows a typical tieback during construction.

Fig. 1. Tieback retaining wall during construction

Four steps has been used in KZP6 method. The Steps are:
Step 1- Define Design parameters
Step 2- Determine external earth pressures
Step 3- Check the preliminary depth of piling penetration of the wall system
Step 4- Check the preliminary number of tieback tiers with respect to pile depth and overall stability.
The required design factor of safety for pile penetration is about 1.3.

Estimating Tieback Anchor Capacity for Design

Determining or estimating the bond (resisting) capacity is a prime element in the design of a tieback anchor. For most of the temporary shoring work normally encountered, the tieback anchors will be straight shafted with low pressure grout. For these conditions the following criteria can generally be used for estimating the tieback anchor capacity (Fig. 2). Just the length of the ties in the resistant zone will provide the anchor capacity, and the tie pullout resistant in the active zone will be neglected. For example the anchor capacity length for the top tie would be L1-L11 as shown in Fig. 2. Pullout force for the first tier is calculated from equation (1).

$$Pult1 = \pi.D(L1\text{-}L11).\gamma.(hm1+hma).(TAN(\Phi)) \qquad (1)$$

D, γ are grout diameter and soil unit weight respectively and hmi+hma is the height of the soil above the center line of the pullout resistant length for each tie (just showed for the first tier in Fig. 2). It is important to check the Pult for each tie to make sure they are less than the tie allowable tension forces, and if Pult was greater than the allowable tie tension force, the allowable nail tension force should be considered as Pult.

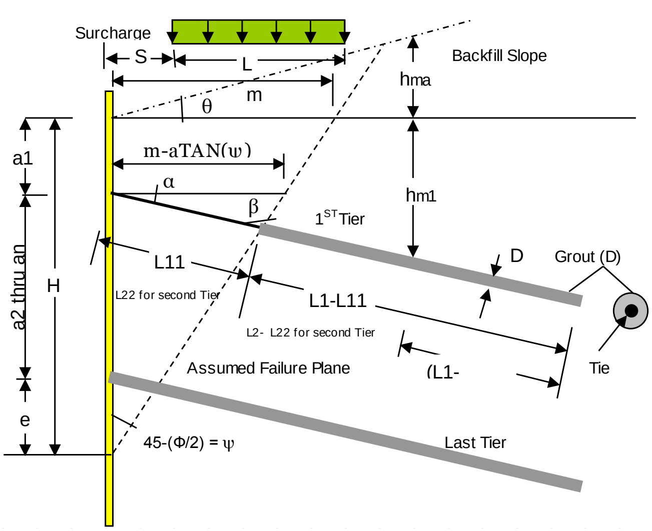

Fig. 2. KZP6tieback parameters and zones

Surcharge load with the length of "L" and distance "S" from the face of the wall is considered based on KZP1 & KZP2 methods.

Active pressure "Pa" and passive "Pp" forces would be soil pressure with taking into account the backfill slope on top of the wall. Tie distances from the overturning point "O" and active and passive forces are shown in Fig. 3. The active and passive soil pressure coefficient for a vertical tie back wall with a continuous slope above the top of the wall (Fig. 3) is determined using the equations (2) & (3).

$$Ka=COS(\theta)\{COS(\theta)-[(COS^2(\theta)-OS^2(\Phi)]^{0.5}\}/\{COS(\theta)-[COS^2(\theta)-COS^2(\Phi)]^{0.5}\} \qquad (2)$$

$$Kp=COS2(\varphi)/[COS(\sigma)[1-SQRT(SIN(\varphi+\delta).SIN(\varphi+\beta)/(cos(\delta).COS(\beta))]^2 \qquad (3)$$

Φ = Internal soil friction angle
θ = Embankment slope angle

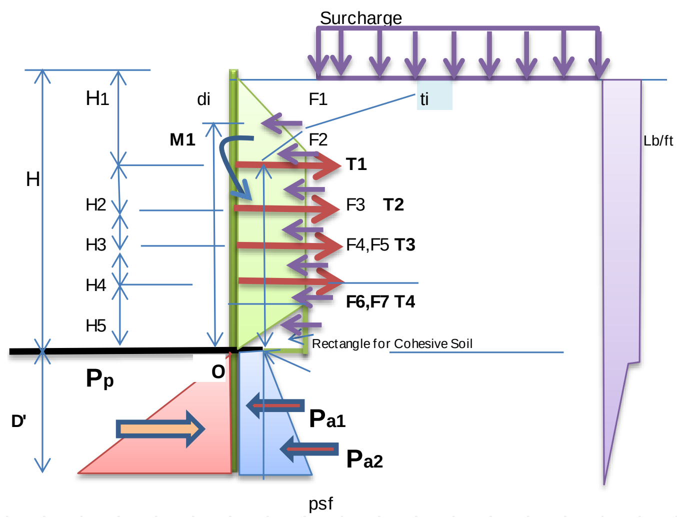

Fig. 3. Soil pressures and tie distances from O

Overall system stability actors of safety will be calculated from equation (4).

$$\text{Overall stability F.S} = a/(H+D)>1 \qquad (4)$$

In which:
a = Horizontal component of the tieback anchor length (Fig. 4)
H+D = The vertical member's total length

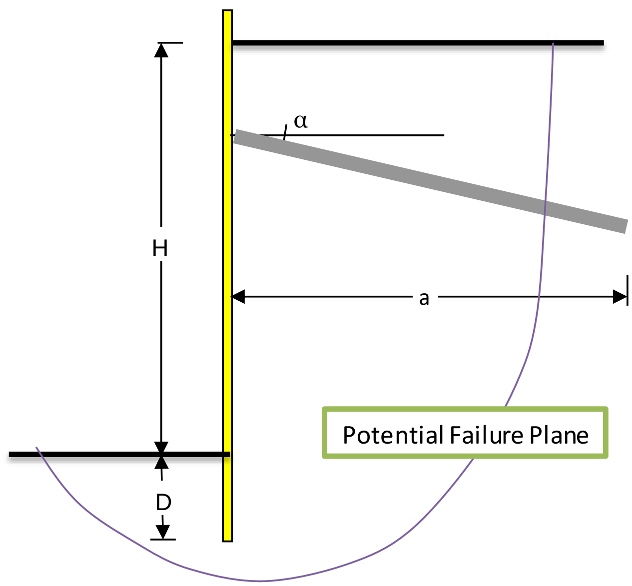

Fig. 4. Dimensions for the overall stability calculation

In order to find the pile maximum bending moment, with considering the pile embedment the zero shear location throughout the pile length will be calculated that can be above our below the bottom of the excavation.

A computer program is written for this trial and error method and the designer will be able to change the pile embedment length to get the moment equilibrium between the resisting moment caused by the tiebacks and the passive pressure and the soil and surcharge pressure. After finalizing the pile embedment, the pile maximum shear along with the factored embedment length will be calculated.

EXAMPLE

The unit weight (γ) and internal friction angle (Φ)of the silty sand are 115pcf and 35deg respectively. A design live surcharge load of 100pcf is considered to be applied uniformly across the ground surface at the top of the wall. The face is vertical, and other parameters for steps 1 & 2 are as follows;

Steps 1 & 2:
H (Height of the wall) = 39ft
Φ = 35deg
H1 (Vertical distance of the top tieback from the top) = 8ft
H5 (Lowest tieback distance from the bottom) = 4ft
θ (Embankment slope angle) = 0.0 deg
α (Angle of inclination from horizontal of tieback)= 20 deg
δ= (Angle of the wall friction) = 11deg
Vertical and horizontal distance between the ties Hi = 9ft and S_H = 7.5ft.
Step 3:
$Ka = Tan^2(45- \Phi/2) = 0.28$
Kp= 4.98
σa = 911 psf
σc = 1255.8 psf
Step 4:
Find the pile embedment (D) to satisfy moment equlibrium. First try for all four tiers is 16ft. Table 1 shows the final factor of safety for different nail length considerations.

Table 1. Pile embedment length, maximum moment and factor of safety per KZP6 method

Pile embedment Length & Maximum Moment		Factor of safety
D'(ft)	M(ft.k)	Overturning
6.38	125.6	1.3

This example has been solved with other software and results are shown in Table 2.

Table 2. Pile embedment length, maximum moment and factor of safety per other method

Pile embedment Length & Maximum Moment		Factor of safety
D'(ft)	M(ft.k)	Overturning
6.89	128.7	1.3

Comparing the results will show the accuracy of the KZP6 method, and the difference is about 5%.

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